

Inter-device power management for audio/video equipment

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Abstract-- Electronics are an increasing fraction of electricity use in buildings, with those devices that support audio and visual display one of the largest portions. Collections of interconnected A/V devices in buildings are becoming larger as they become networked to A/V devices in other rooms, to traditionally IT devices, to non-electronic devices, and to the Internet. Managing the power state of such connected devices is increasingly difficult, resulting in user confusion and wasted energy. This paper presents an overall architecture for how power state could be managed automatically in the future to both increase user amenity as well as reduce energy use.

I. INTRODUCTION

A precondition to use of audio/visual devices is that the required devices are powered up when needed, and except for displays, doing so is unrelated to their functionality. One approach is to leave devices on continuously to ensure they are always available when needed, but most devices are not actively used most of the time resulting in waste. Products can be powered up and down manually, but this is cumbersome and often the powering down does not occur. This situation is not optimal for either user experience or energy consumption. This paper explores an alternative approach in detail improving energy use and the user experience.

II. THE PROBLEM

At one time, the typical TV was not connected to other devices. Today however, most are connected to several, with the number rising. These other devices can be powered up and down with manual power switches, with power buttons on remotes, and in limited cases, by other devices they are networked to (though this usually requires special configuration or particular products from the same manufacturer and technology base). However, manual control is problematic for several reasons:

- On a practical level, connected A/V devices are increasingly in closed cabinets, in other rooms, or on the Internet.
- Many users do not know what devices need to be on at any particular time, particularly if they are not adept with managing A/V networks and/or did not set up the devices involved. It is often not obvious what devices need to be on for a particular function, and today, which devices even *are* on.
- Activity is increasingly initiated by a device rather than

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directly by the user (e.g. automated recording of content).

Thus, the traditional model of “manual” power control (whether directly or with a remote control) is becoming obsolete and needs to be replaced. A promising approach is automatic behavior that can be summarized as:

“wake up when you need to; go to sleep when you can.”

III. CONFOUNDING FACTORS

Addressing this problem would be easiest if all communications were digital, networked and used the same physical and application layer protocols. Unfortunately, legacy analog interfaces will likely retain at least the potential for use for many years to come. Other links are digital but not true network links. Finally, there are a large number of physical layers in use, with many diverse application layers.

These factors are not fatal to the goal; rather, they just make the solution more complicated and slow progress towards it.

IV. ALTERNATIVES

One alternative is for devices that have a need for services from others to command those others to power up, and when the service is no longer needed, to order them to power back down (a “command and control” approach). This is used by some proprietary technologies, with the TV generally acting as the control device as it is the most common receiver of content signals.

Another method is to embed the automated command functionality into remote controls. These can be successful in certain contexts, but have several problems. One is that power commands in existing A/V communications technologies are often a single power command to toggle the power state. Thus, if the other device is not in the state the controlling device expects, it can do the opposite of what is intended. Also, as devices increasingly can deliver services to devices other than the primary TV, the TV does not necessarily know if a device is providing a function and so lacks the knowledge to make the right decision. Finally, this approach is “brittle” in that it is easily broken by changes in the set of devices present.

Note that a power button on a remote control is usually functionally equivalent to one on a device itself. Some devices may listen to remotes they are in direct communication with, but not those only visible on the network.

V. THE SOLUTION

The best solution is one that embraces device autonomy and self control, along with standard behaviors. That is, each device should be aware of what services it is providing, and inform other devices as best it can about relevant services it is

using. Since we will long have legacy interfaces that impair having such information exchange, reasonable compromises need to be embedded in how devices behave.

An important precedent for this, albeit a much simpler one, is the operation of monitor power management with PCs. The PC signals to the monitor when it should go to sleep by ceasing to send synchronization signals on the data link. It later indicates when the monitor should wake by resupplying these signals. Today, many monitors can sleep at the same power level as they use when off, showing that efficient sleep modes are possible with well-designed protocols.

Operation of the solution may be best illustrated and understood by a few examples.

- A TV is powered up, and a DVD player is selected as the source; this should cause the DVD player to wake and start its menu sequence. The user then selects 'play' and begins watching a DVD.
- The TV is later shifted to broadcast television in the midst of the DVD (which then pauses). The TV stays away from displaying the DVD signal for 15 minutes, at which point the DVD player powers down to sleep.
- Another time, the DVD finishes a movie and shifts to its menu mode. After 15 minutes of being in menu mode with no user input, it goes to sleep; the DVD signals its transition to sleep (or simply ceases to send a display signal to the TV) which causes the TV to also go to sleep (possibly briefly displaying a message to this effect).
- A set-top box is delivering content to a TV, via an analog connection that does not allow it to know the power state of the TV. Four hours pass with no user interaction to the set-top box, so it overlays a message of imminent power down for five minutes, then goes to sleep. If the TV is not already asleep, it also does so with the lack of signal.

These examples highlight key aspects of the solution:

- Exposing power state over the network, i.e. whether the device is fully on, or asleep (and possibly expose off).
- Exposing functional state over the network, e.g. what data streams are actually being consumed, whether a media source is loaded (e.g. DVD or iPod), and time since last user input activity.
- Default device behavior, including time-delays suitable to human behavior and expectations. These should be long enough so that most transitions occur after people are no longer engaged with the product.
- Devices taking into account power and functional information from other devices to determine what they should do, and
- Devices going into a sleep state rather than to off as the normal low-power state.

VI. IMPLEMENTATION

Moving to the comprehensive solution will require a set of interoperability standards that cross multiple data interface types as well as user interfaces. It requires action on the part of standards organizations, energy policy makers, and manufacturers of audio/visual products. Key actions are:

- Creation of a "meta-standard" that defines general approaches, principles, and behaviors that lead to the desired result.
- Implementation of this scheme in standards for specific interfaces, protocols, and products (e.g. HDMI, UPnP, and other emerging IP-based protocols). Some standards already include some of the needed functionality.
- Explicitly moving to a 3-state power model, where sleep implies continuous network presence, and off does not. This drops "standby" as a power state which is ambiguous on this key point and others.
- Adoption of this system by energy policy as a prerequisite for considering an audio/visual product as efficient (initially for voluntary specifications and later for mandatory requirements).
- Adoption by the manufacturers of audio/visual products, both in new products and with software upgrades to some existing products.
- Explanation of it to ordinary users of products, particularly for the complications introduced by legacy products.

Accomplishing all of these is not trivial and will take some time, but there are no fundamental barriers to doing so. In particular, the useful functional advantages it offers people may drive manufacturer and consumer acceptance, with the energy savings only a useful side-benefit.

Some connected devices will have principal functions other than audio/visual content, e.g. personal computers. These will also need to implement parts of the proposed system.

VII. SUMMARY

All future A/V devices need to adopt the principle of automatic behavior summarized as "wake up when you need to; go to sleep when you can." This implies that they are usually asleep, and so maintaining connection to the network, not on (and wasting energy), or off (and not connected to the network). Devices need to move to an explicit 3-state power model internally, as exposed to the network, and exposed to the user.

Development and implementation requires action in standards organizations, energy policy, and manufacturers. Functional benefits may be a bigger part of the story in the long run than the energy savings they enable.

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REFERENCES

- [1] Institute for Electrical and Electronic Engineers, IEEE 1621, "Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments", December 2004 (reaffirmed December 2009).